

COMMONWEALTH OF PENNSYLVANIA.

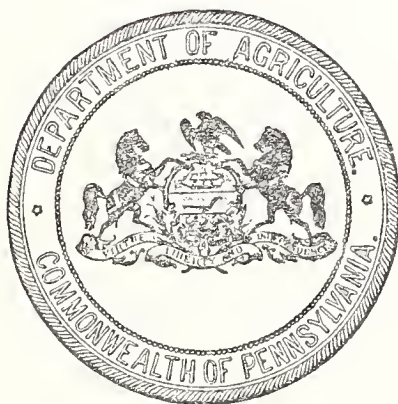
DEPARTMENT OF AGRICULTURE.

BULLETIN NO. 96.

Insects Injurious to Cucurbitaceous Plants

BY

H. A. SURFACE, PROFESSOR OF ZOOLOGY, PENNSYLVANIA STATE COLLEGE.



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CONTENTS.

	Page.
Preface,	5
Letter of transmittal,	7
Cucurbitaceous plants,	9
Insects,	9
General remarks on insects,	9
Classification of insects,	10
Stages in their life history,	10
Growth, methods of feeding, and general remedies,	10
The species of insects attacking cucurbitaceous plants,	11
Order Physopoda; The thrips, etc.,	11
Family Thripidae thrips,	11
Thrips tabaci; Tobacco thrips or onion thrips,	11
Order Hemiptera; The bugs, plant lice, scale insects, etc.,	11
Family Coreidæ; The squash bugs,	11
Anasa tristis; The squash bug,	14
Family Aphidæ; The plant lice, aphids,	14
Aphis gossypii; The melon louse,	14
Aphis cucumeris; The cucumber louse,	14
Order Lepidoptera; The scale-bearing insects (moths, butterflies, etc.),	14
Family Pyraustidæ; The pyraustids,	14
Endioptis nitidalis; The pickle moth,	15
Margaronia hyalinata; The melon worm,	15
Family Sesiidæ; The clear-wings,	15
Melittia ceto; The squash borer,	16
Order Coleoptera; The beetles,	16
Family Coccinellidæ; The lady-bug,	16
Epilachna borealis; The herbivorous lady-bug,	17
Family Chrysomelidæ; The leaf beetles,	17
Diabrotica 12-notata; The spotted cucumber beetle,	17
Diabrotica vittata; The striped cucumber beetle,	18
Systema blanda; The white-striped flea-beetle,	18
Systema elongata; The elongate flea-beetle,	18
Crepidodera cucumeris; The cucumber flea-beetle,	19
Order Diptera: The flies,	20
Preventives and remedies,	20
I. Mechanical devices,	20
1. Netting,	20
a. Netting over basket support,	20
b. Netting over inclined stake,	20
c. Netting attached to end-boards,	20
d. Netting unsupported,	21
2. Paper tents,	21
3. The tarred board or cloth,	21
4. Board traps,	22

	Page.
II. Farm practice,	22
1. Clearing away all rubbish,	22
2. Destroying all unused portions of crops as early as possible,	22
3. Killing all weeds,	22
4. Rotation of crops,	23
5. Planting trap crops,	23
6. Hand picking,	23
7. Excessive seeding,	23
8. Using fertilizer,	24
9. Starting crops early,	24
10. Late fall ploughing,	24
II. Early application of all preventives and remedial measures, ..	24
III. Insecticides,	24
A. Stomach poisons, :.....	25
1. Paris green,	25
2. London purple,	26
3. Arsenate of lead,	26
4. Arsenite of lime,	26
5. Bordeaux mixture and Paris green,	26
B. Contact applications,	27
6. Kerosene mixture,	27
7. Kerosene emulsion,	27
8. Whale oil soap,	28
9. Carbon bisulphide,	28
10. Gasolene and benzene,	28
11. Calcium carbide,	28
12. Tobacco,	29
13. Sulphur,	29
14. Land plaster,	29
15. Air-slaked lime,	29
Other invertebrate animals injuring cucurbitaceous plants,	29

PREFACE.

Harrisburg, Penna., July 1, 1902.

The following Bulletin No. 96, by Prof. H. A. Surface, Professor of Zoology in the Pennsylvania State College, upon "Insects Injurious to Cucurbitaceous Plants," has been prepared, at the request of the Secretary, because of the many reports, that have come to this office, of serious injury by insects to cucurbitaceous plants during the past year.

One prominent pickle grower and canner has reported, that the Squash Bug had destroyed scores of acres of squash and cucumber plants in his locality, and that they were at that time, (the last of July, 1901), rapidly destroying the plants of the third planting.

The Department, therefore, engaged the services of Professor Surface, to investigate this subject, and prepare in bulletin form, the results of his investigation, and advise also, such remedies as his knowledge and experience would suggest.

A careful study of this bulletin, will, it is believed, greatly assist our market gardeners and farmers who are engaged in the growing of melons, squash, pumpkins and cucumbers, to overcome the difficulties that now beset them, in the prosecution of this important industry.

JOHN HAMILTON,
Secretary of Agriculture.



LETTER OF TRANSMITTAL.

Harrisburg, Penna., June 28, 1902.

Hon. John Hamilton,
Secretary of Agriculture:

Sir: In accordance with your request, I have prepared the following Bulletin upon "Insects Injurious to Cucurbitaceous Plants."

The season of 1901 was one of unparalleled destruction by certain species of insect pests, notably those affecting the cucurbitaceous plants.

Information, as found in the standard publications, as to the best methods of dealing with insects affecting this class of plant life, is so meagre and unsatisfactory, that I have been compelled to make some experiments in this direction, specially as to the Squash Bug (*Anasa tristis*) which has been so destructive for the pickle growers of this State.

There is given, therefore, in this Bulletin for the benefit of practical vegetable growers, the results of such studies and experimentation as I have been enabled to make upon this subject.

The material has been prepared in a concise and popular form, giving the latest information upon the insects injurious to cucurbitaceous plants, their life histories, habits, enemies, and especially the practical means of suppressing them.

All of the illustrations, excepting three (Nos. 18, 19 and 25), are photographs, directly from nature, taken and finished by the author. Most of them were taken with a vertical or inclined camera, and some were made with the micro-photographic apparatus and low power of the compound microscope.

Respectfully submitted,

H. A. SURFACE,
Professor of Zoology, Penna. State College.





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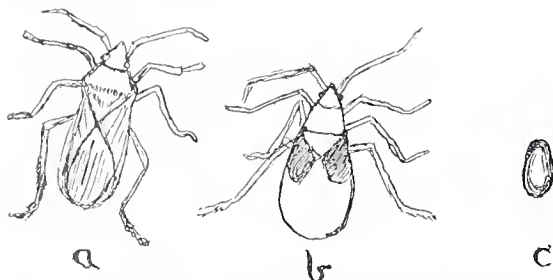


Fig. 1. Three stages of the Squash Bug (*Anasa tristis*), (a) adult, (b) nymph, (c) egg, x2. Drawn by E. L. Westlake, from a photograph by the author. (Reduced.)

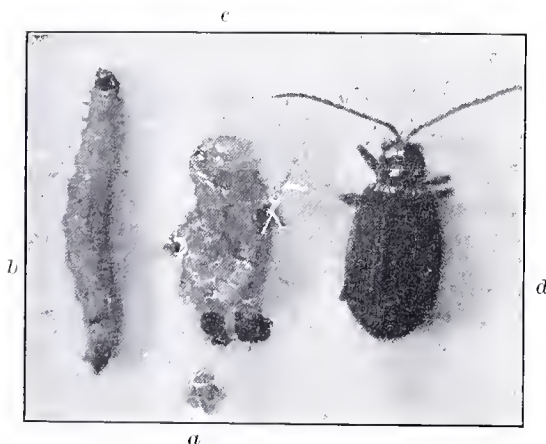


Fig. 2. The four stages of the Striped Cucumber Beetle (*Diabrotica vittata*), magnified five diameters; a. Eggs; b. Larva; c. Pupa; d. Imago.



Fig. 3. Illustration of Insects with Sucking Mouth-parts. Beak partially extended. (Reduced.)

INSECTS INJURIOUS TO CUCURBITACEOUS PLANTS.

BY H. A. SURFACE, *Professor of Zoology, Penna. State College.*

CUCURBITACEOUS PLANTS.

By the above term is meant those plants that belong to the botanical family *Cucurbitacæ*. Although they are all vining plants, one could not give them the common name of "The Vining Plants," because such a term would apply as well to sweet potatoes, grapes, etc. Belonging to this family are the following: Watermelon and citron, muskmelon or cantaloupe, cucumber, squash, gourd, cashaw, pumpkin, etc.

The citron is but a variety of watermelon that is used for preserving, as regular citrons of commerce are preserved. Muskmellons and cantaloupes are identical, although some persons have attempted to indicate differences.

INSECTS.

GENERAL REMARKS ON INSECTS.

Since the insects that attack one species of these plants are found more or less injurious to all of the family, we shall not make a separate list of species of insects for each kind of plant, but shall discuss them in their consecutive entomological order. We refer for the practical measures of each to the separate discussions of preventives and remedies given in the latter part of the bulletin.

CLASSIFICATION.

In order to understand the principles of the classifications, life histories, and remedies given later, it is necessary to bear in mind the following fundamental facts concerning insects:

The class of insects (*Insecta*) is divided into large groups called Orders, and the latter are in turn divided into smaller groups, each called a Family. Families contain yet smaller groups called Genera and the final division of the latter is Species. The scientific name of an insect is the name of its genus and species written in the order here indicated. The classification of an insect is its order, family, genus and species. In the following pages we have expressed the classifi-

cations of the insects to be treated by naming the order and family and giving the scientific name of each.

Orders and families are founded upon certain common important structures, the more potent and general of which characterize all insects belonging to the major group. There are nineteen orders known to modern entomologists, but the insects treated in this bulletin represent only five of these.

STAGES IN LIFE HISTORY OF INSECTS.

Insects undergo transformations called metamorphoses. In their life cycle they exist in certain forms called stages. Those treated in this bulletin have either three or four stages, according to their kind of metamorphosis. It may be "Incomplete," in which the insect has but three stages: (1) The egg, (2) nymph or immature, and (3) imago or adult. (See Fig. 1.) In this group the young resemble the adult in form and generally in habits, lacking only the wings. There is no worm-like existence and no pupal or quiescent stage. The squash bugs and grasshoppers are good examples of insects with incomplete metamorphosis. The young are called nymphs.

The representatives of the next group, or those with complete metamorphosis, pass through four stages: (1) The egg, (2) the larva, or worm-like stage, (3) the pupa or resting stage, and (4) the imago, adult or mature insect. (See Fig. 2.) The young are called "larvæ" and do not at all resemble the adults. They are popularly known as "worms," but this common name should not be given them, since worms are independent creatures that do not transform into any other form or stage. (Example, the earthworm).

Insects grow only in the nymph or larval stages. They do not become larger after having once reached the adult or winged stage. They live in the latter condition but a few days or weeks, mate, lay their eggs and then die.

Some adult insects do not eat; others, like the butterflies, only sip a little nectar and do not have feeding habits similar to their young. Others, like the squash bugs and cucumber beetles, eat the same kind of food as do their nymphs or larvæ.

The feeding habits of insects is a fundamental feature in applying insecticides. Some have biting mouthparts with strong jaws and chew the leaves or tissues of the plant. (Examples, caterpillars, beetles, etc.) These insects that chew can nearly always be killed by poisons, which are to be taken internally, among which the arsenites are prominent, and Paris green is the most valuable. (See Insecticides, A, p. 25.) The insects that do not chew their food have piercing mouth-parts, as has the squash bug. (See Fig. 3.) As they are suctional and do not suck before the bill is inserted, they are not affected by poison lying on the leaf. They must be killed by contact applica-

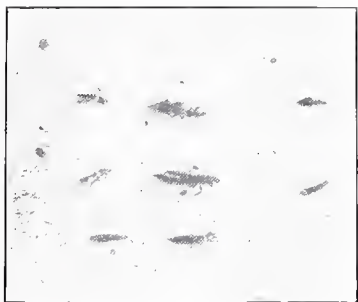


Fig. 4. Different Species of Thrips, five times natural size. The one at the upper left corner is a nymph without wing-pads.

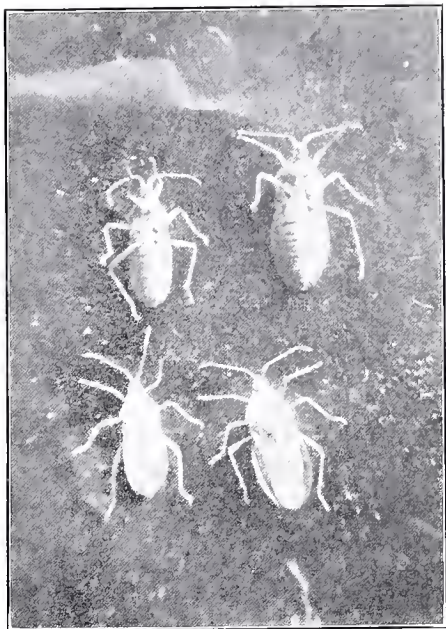


Fig. 5. Adult Squash Bugs (*Anasa tristis*), natural size. Dorsal or upper side shown by the two below; ventral or under side shown by the two above. The two at the reader's left are males, and the two at the right are females.



Fig. 6. Squash Leaf Crumpled, showing effects of Squash Bugs. The colony of bugs living within its folds could not be entirely exterminated by spraying with kerosene. The best treatment for such a leaf is to carefully cut it off and either crush it under one's foot on the ground or drop it into a vessel containing kerosene on water.

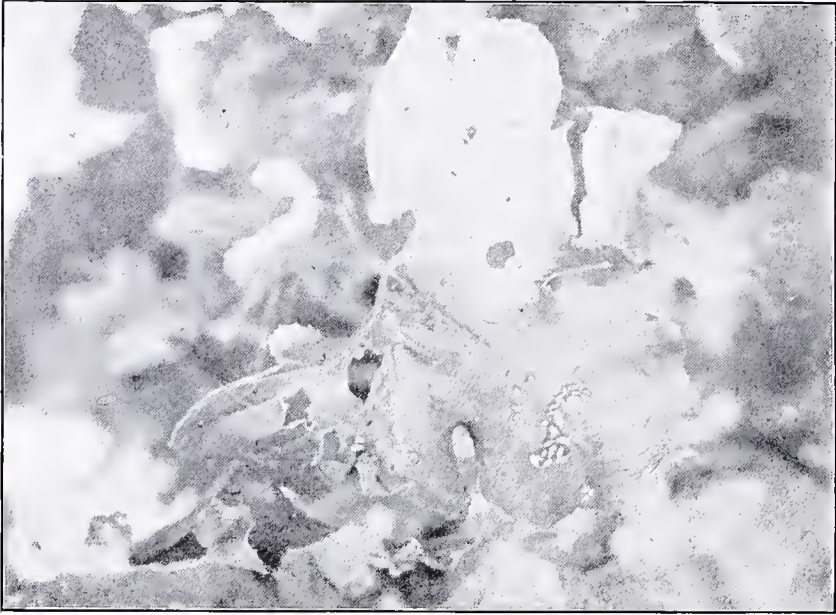


Fig. 7. A colony of young Squash Bugs, of different ages, showing gregarious habits. In such a position as this they are readily reached by kerosene emulsion or kerosene mixture.



Fig. 8. Eggs of the Squash Bug (*Anasa tristis*), natural size, *in situ*, on the under side of a squash leaf. This shows the regular distance between the eggs, the diagonal direction of the rows, and the irregular shape of the patch as a whole.

tions (See Insecticides, B, p. 27), which kill by entering the breathing pores, but not the mouth.

THE SPECIES OF INSECTS.

ORDER PHYSOPODA: Family Thripdæ: Thrips. (Fig. 4.)

Tobacco Thrips or Onion Thrips (*Thrips tabaci*).

The Thrips are among the most minute of insects. Their mouth-parts are fitted partially for sucking and partially for biting, but mostly the former. They do not eat away the tissues of the plant, but pierce the leaves and cause small white specks which may become so abundant as to give the plant a grayish appearance. These insects are from one-sixteenth to one-fortieth of an inch long and about one-fifth as wide. They are dark in color and have four very minute wings fringed with long hairs which increase their surface area and flying capacity. When disturbed they suddenly disappear by jumps or short flight.

This species has been reported feeding on sixteen species of plants, besides on melons, squash and cucumbers; mostly on onions and cabbage, where they are at times very destructive.

Their habit of sudden jumping flight gives the key to the remedy for them, which is Mechanical Device No. 3. They will fly down the wind and be carried against the tarred cloth or board held in their path of flight to the leeward. They can of course be killed by contact applications; also by Mechanical Device No. 3, p. 21, and by insecticides 6 to 12, pp. 27-29.

ORDER HEMIPTERA: The True Bugs, Plant Lice, Scale Insects, Etc.

FAMILY COREIDÆ: The Squash Bugs. (Fig. 5.)

The Squash Bug or "Stink Bug" (*Anasa tristis*).

The squash bug is about five-eighths of an inch long and one-fourth of an inch wide, with antennæ half the length of the body. The head is dusky, nearly black; thorax or part to which the wings are attached, dark brown; scutellum or triangular piece between the wings, dusky; sides of abdomen or posterior part banded with six yellowish bands; upper wings dark and brown or grayish at basal half and sooty black toward the tips, which are thinner; the under wings are smaller and very thin and gauze-like toward the base and

dark toward the tips. The legs are long and slender, the hinder pair measuring half of an inch in length. The suctorial beak is very long (one-fourth inch), sharp and slender, and reaches back on the ventral side to the base of the hinder pair of legs. (See the upper specimens of Fig. 5.)

The nymphs are much broader in proportion to length than are the adults. The adults of these insects fly readily by day and are not attracted to lamp traps at night.

This common and well-known insect is the most destructive of the pests infecting Cucurbits toward the middle and latter part of the summer. It appears about the last of June and is found on the vines or fruit until after frost comes. The first one found by us was on a plant just about sprouted, on the 15th of June. They feed on all Cucurbits, by sucking out the juice of the plant. According to the habit of many other bugs, they inject a poisonous saliva into the plant and this turns the leaves dark in spots and causes them to wither, crumple and soon turn brown. (Fig. 6.)

They are social insects, living in groups under the crumpled leaves and under or sometimes upon the large leaves that lie on the ground. (Fig. 7.) The first mating occurs in the latter part of June and the first eggs are deposited in the early part of July. The eggs are large, oval and at first are white and adhesive. They gradually become cream colored, reddish brown, and wine red; later they become bronze red, and shortly before hatching are nearly black. They are deposited in diagonal rows in irregular-shaped patches, generally beneath the leaves, but sometimes above. (Fig. 8.) The distance between them is equal to one-half the width of the tip of the abdomen of the female. They are very conspicuous and can readily be detected for the remedies given below. The number in a patch varies from a very few to over fifty. They hatch in from ten to sixteen days, according to temperature, hatching sooner when the weather is warmer. They are so plainly seen that they can readily be destroyed. They adhere too firmly to be easily picked off, and we have found that they can be painted with a touch of pitch and killed. Painting with pure kerosene does not always prevent their hatching.

The very young bugs are very brightly colored. Their bodies are light green and their legs and antennæ are bright red. Within an hour the appendages turn dark and become black. The young bugs live in groups (Fig 9) and moult several times. They finally obtain wing pads and the next moult they have wings and are adult. After the final moult they are at first white, but in a few minutes become dingy brown, then darker, and in a few hours grayish. Soon they pair and the females afterwards lay from one hundred and fifty to three hundred eggs. A second laying of eggs often ensues and thus the second brood may appear. They have the same appearance and

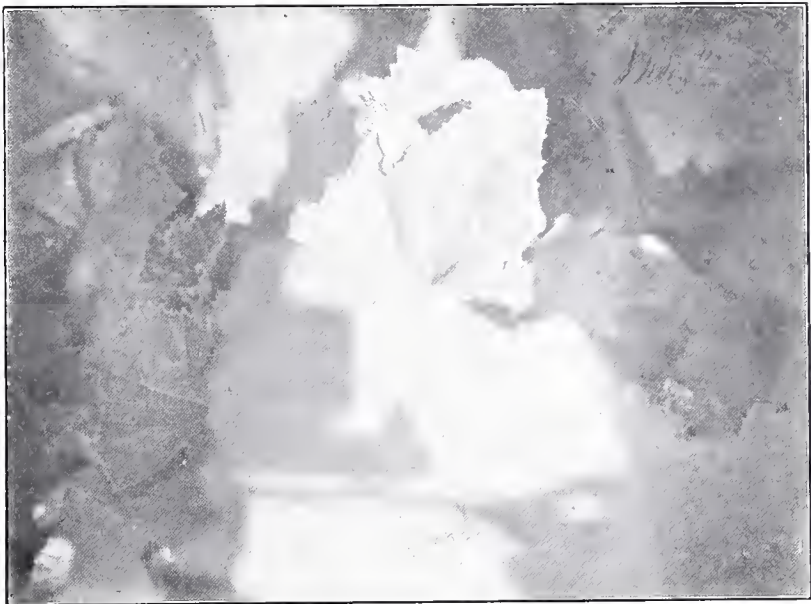


Fig. 9. Eggs and Nymphs of Squash Bugs, one-fifth natural size. The young have recently hatched and remain in a group near the egg shells, which adhere to the leaves all summer.



Fig. 10. A group of Squash Bugs on a dead leaf in the Fall, showing where they can be killed by a stronger kerosene spray.

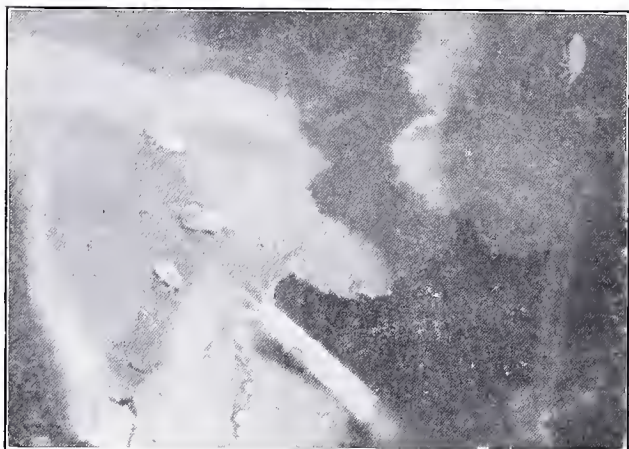


Fig. 11. All stages of the Squash Bug (*Anasa tristis*) At the left of the center is the female, laying eggs, below the center is a row of eggs, and below and above the female are nymphs without wing-pads; while at the upper right corner is an older nymph with wing-pads. Photographed in the field, with the insects alive and in their own natural positions. One-fourth natural size.

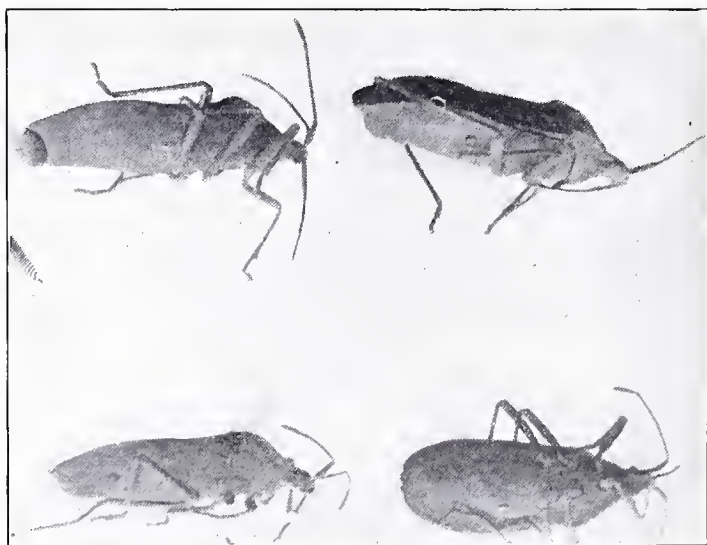


Fig. 12. Eggs of Parasites on Squash Bugs. It was through the abundance of these parasites, destroying the fall brood of 1901 after it became adult, that the bugs are rare and crops are free from serious injury during the season of 1902. Slightly more than twice natural size.

habits as the first brood. In the northern part of the United States there is but one brood. When the weather is cool they go under cover for protection, and come out into the sunshine to be warmed. (Fig. 10.) At night they seek the cover of a leaf, the under side of a board, etc. (See Fig. 44.) This habit leads them to their destruction where board traps are used. (See Mechanical Device No. 4.)

In the fall of the year the insects are quite likely to collect on the green fruits of the vine and suck juices from them after they can no longer derive any from the leaves. This is the time that they should especially be killed by kerosene spray or sprinkling to prevent their scattering and living through the winter to become the progenitors of next year's pests.

As the broods are not sharply separated, but some individuals lay early and others lay later and the laying and hatching continues throughout the season, all stages can be found at one time, and there is the appearance of continuous breeding. (Fig. 11.)

The winter is passed in hibernation in the adult stage, sometimes far away from the places where the infested plants grew. They hibernate in woods, along fences, in rubbish, under boards, especially in lumber piles, in grass, sod, etc. On account of their offensive odor they have no conspicuous vertebrate enemies, such as snakes, toads, birds or skunks, as have many other species of insects, but they are greatly infested with the larvæ of parasitic flies (*Tachina*). When the bugs become abundant, as in the summer of 1901, these parasitic flies multiply in the first brood and become so numerous in the second brood as to materially reduce the number of adults going into hibernation. In fact last fall we could not find one adult that did not have upon its body one or more eggs or parasites (Fig. 12) and under or near these empty egg shells there could be found the tiny hole where a young fly larva had bored into the interior of its host. Owing to this fact we then predicted that there would be but few squash bugs during the season of 1902, and this prediction was fulfilled to a remarkable degree.

REMEDIES.

Since these are sucking insects and do not bite the plants, they cannot be killed by poisons. The only remedies that can be effectively employed against them are clean farming, hand-picking, mechanical contrivances (Nos. 1, 2 and 4, described later), contact sprays and painting the eggs with something like pitch to destroy them.

To prevent next year's brood it is important that the vines be destroyed and the green fruits be removed just as early as possible in the fall. If this were universally done there would be no bugs of the second brood coming to maturity.

ORDER HEMIPTERA: The True Bugs, Plant Lice, Scales, Etc.

FAMILY APHIDIDÆ; The Aphids.

The Melon Louse (*Aphis gossypii*), and The Cucumber Louse (*Aphis cucumeris*).

The Melon Aphids are very small, greenish insects with globose bodies not an eighth of an inch long. Some of the adults are wingless and some are winged. As they belong to Hemiptera they agree with all insects of this large order (excepting the male scale bugs) in having only the three stages in their life history: Egg, nymph and adult. Yet the plant lice are parthenogenetic or give birth to succeeding generations of living young without mating for each generation. When winged there are two wings on each side of the body. These are long and delicate and so close together that they would be taken for a single pair. All plant lice are suctorial, feeding by sucking out the juices of the plant. They live mostly on the young leaves, terminal buds, and the unopened flowers, where their damage is greatest. (See Fig. 13.) Their effect is to check the growth and distort and crumple the leaves. The two species named above are so nearly alike in appearance and effects that no difference is to be made in this treatise. They feed on dozens of different kinds of plants, cultivated and uncultivated, and they are therefore quite difficult to exterminate.

They have probably more natural enemies than have any other kind of insects. Among these are many insectivorous insects, such as lady bugs or lady beetles, Syrphus fly larvæ (Fig. 14), minute wasp-like internal parasites, the Aphis Lion or larva of the Lace-wing, etc. (Figs. 15, 16, 17.) They are also the common food of most small insectivorous birds, and are killed in great numbers by a fungus.

They may prove serious at times if no efforts are made to prevent them, but if taken early enough in the season they are easily held in check by Mechanical Devices Nos. 2 and 3; Farm Practice Nos. 2, 3 and 4; insecticides Nos. 6, 7, 8, 9, 10, 11, 12 (a and b), and 15.

ORDER LEPIDOPTERA: Moths, Skippers and Butterflies.

FAMILY PYRAUSTIDÆ; The Pyraustids.

The Pickle Moth (*Endioptis nitidalis*) (Fig. 18.)

The larva of this moth bores into the fruits of squashes, melons, cucumbers and cushaws, feeding on the fleshy pulp, causing it to decay. It is quite a pretty brown and yellow insect called "the pickle

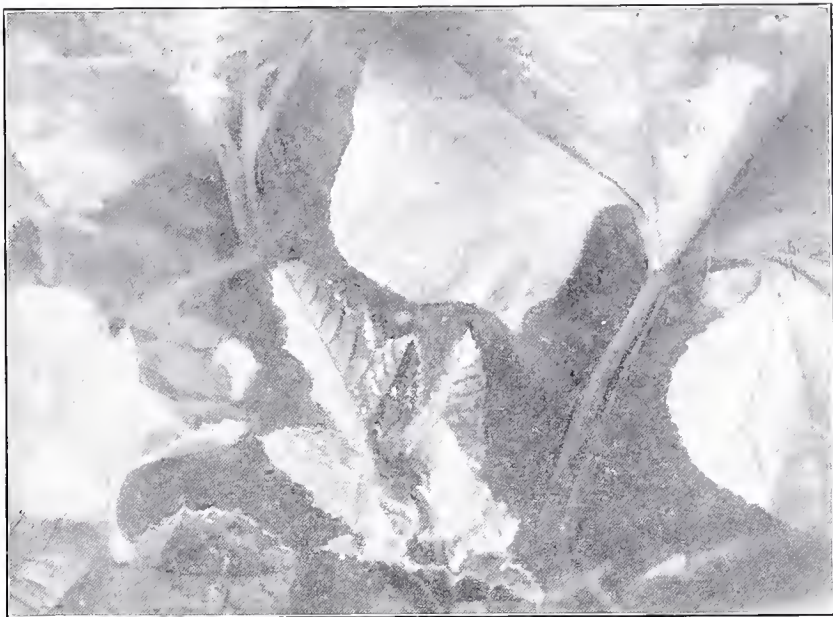


Fig. 13. Plant Lice (*Aphis*) on the unopened blossoms and young leaves.



Fig. 14. Syrphus Flies. Very important enemies of Plant Lice on all kinds of plants, (a) Eggs; (b) Larva alive and eating an *Aphis*; (c) Adult. Twice natural size. The Larva is not the same species as egg and adult here shown but is larger. It is surrounded by the remains of the Aphids it has devoured.



Fig. 15. *Aphis* and its Enemies. This photograph shows some live Plant Lice, both old and young. Some that were killed by fungus, some exuviae or cast skins of Aphids. *Syrphus* Fly eggs and larvæ (at X), and Lady Beetles. Nearly natural size.

moth, because the caterpillar has the habit of feeding upon the cucumber, boring into and destroying it when about half grown. It is more common in the western States, and no satisfactory recommendations for its control have yet been made.”—(Smith).

This insect has not yet found its way to Pennsylvania, but if it does it can probably be successfully combatted by spraying in time with the arsenites (Insecticides, 1-5) before the “worm” enters the fruits. This is to kill it when it commences to feed just as we now successfully contend with the Codling Moth by the same means and upon the same principles.

ORDER LEPIDOPTERA: The Moths, Skippers and Butterflies.

FAMILY PYRAUSTIDÆ; The Pyraustids.

The Melon-worm (*Margaronia hyalinata*). (Fig. 19.)

The melon-worm is another pest of the southern and southwestern States that is not yet common in Pennsylvania. It destroys the leaves of the water-melon and the leaves and fruit of the musk-melon. It is a light yellowish green caterpillar about an inch long.

For all such biting insects the standard remedy would be the arsenites, especially Paris green, No. 1, applied as soon as the first signs of the insect occur and continued weekly for three or four weeks.

ORDER LEPIDOPTERA: Moths, Skippers and Butterflies.

FAMILY SESIIDÆ: The Clear-wings.

The Squash-borer (*Melittia ceto*). Figs. 20 *a* and 20 *b*.)

The insect or so-called “worm” that bores in the stem of the squash, pumpkin and some other Cucurbits is the larva of a moth that is called “a Clear-wing,” because it has a space in its wing that is clear and not covered with scales. The adult or moth measures over an inch in extent of wings from tip to tip, and has the front wings covered with dark green scales. There is a conspicuous tuft of red, white and black hairs on each hind leg which is characteristic and renders this moth easily determined.

It flies by day, as do all clear wings, and at night remains quiet on the leaves of the plant its larvæ infest. On this account it is

easily found and killed by using lanterns at night. It does not fly into lamp traps. In its flight it resembles a wasp.

The moth passes the winter in the ground and appears in this latitude about the last of June.

It lays its eggs singly, either on the vine or on the stalks or petioles of the leaves. The favorite place is toward the base of the vine. We have found many at the top of the leaf stem. (Figs. 21, 22.) When the larva hatches it eats into the interior of the vine or of the hollow leaf stem and follows the latter down and enters the vine. The small hole that it makes can be seen and generally fine borings or dust (excreta) can be seen at this hole. Their presence in the vine can first be detected by the presence of the dust at the small hole.

Because it is an internal feeder it cannot be killed by an insecticide. It should be cut out with a sharp knife, cutting lengthwise of the vine, and dust rubbed on the wound to facilitate healing. The vine should be covered at intervals of a few feet with damp earth over the base of the leaves that roots can be formed there. After the new roots are formed the vine will continue to grow even though it may be entirely cut off at its base. We have grown good crops on plants treated in this way. (Figs. 23 and 24.)

Another method is to plant summer varieties of squash to become large and receive the eggs and larvæ; then after the winter varieties (Hubbards and Marrowtats) are starting, gather the early fruits from the trap crops and destroy the vines by burning.

Mechanical protection from squash borers is not possible because they attack the vines after the latter are too large to be covered by netting advantageously. Pumpkin vines are commonly infested and should be burned as soon as the crop is gathered or when found dying. (Farm Practice, No. 2, p. 22.)

ORDER COLEOPTERA: The Beetles.

FAMILY COCCINELLIDÆ: The Lady-bugs, Lady-birds or Lady-beetles.

The Herbivorous Lady-bugs (*Epilachna borealis*).

The adult beetles of this species are large hemispherical, yellow with black spots. The larvæ are also yellow, elongate, oval, with long branched spines. '*Epilachna borealis* is the northern and eastern species, attacking cucumber, melon and similar vines, while *E. corrupta* is found in the southwest, injuring beans. A curious feature in *E. borealis* is the manner in which the adult works out a circle at the edge of a leaf and feeds within it until all usable ma-



Fig. 16. The Lace Wing Fly (*Chrysopa*.) (a) Egg on stalk for protection; (b) Larva, called Aphidion; (c) Adult Female Lace-wing. This is the individual that layed the egg shown at a. Twice natural size.



Fig. 17. Several species of Lady Beetles, taken from Cucurbitaceous plants, where they were devouring Plant Lice, Insect eggs, etc. Twice natural size. Above are the larva and pupa of a Lady Beetle.

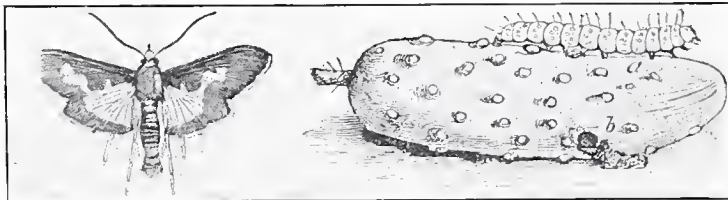


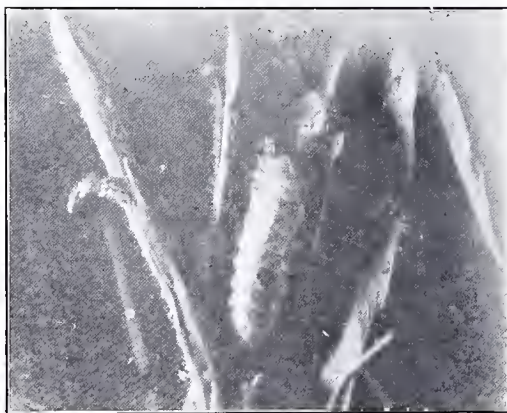
Fig. 18. The Pickle Worm (*Endopiza nitidis*). Reproduced from the Report of the United States Department of Agriculture. (Riley).



Fig. 19. The Melon Worm (*Margaronia hyalinata*).
Reproduced from Saunder's "Insects Injurious to
Fruit."



a



b

Fig. 20. The Squash Borer (*Melittia ceto*). a. Adult Female Moth, natural
size. Photographed from nature, with a vertical camera. b. Full grown
larva, in squash vine, just as it was split open by the writer.

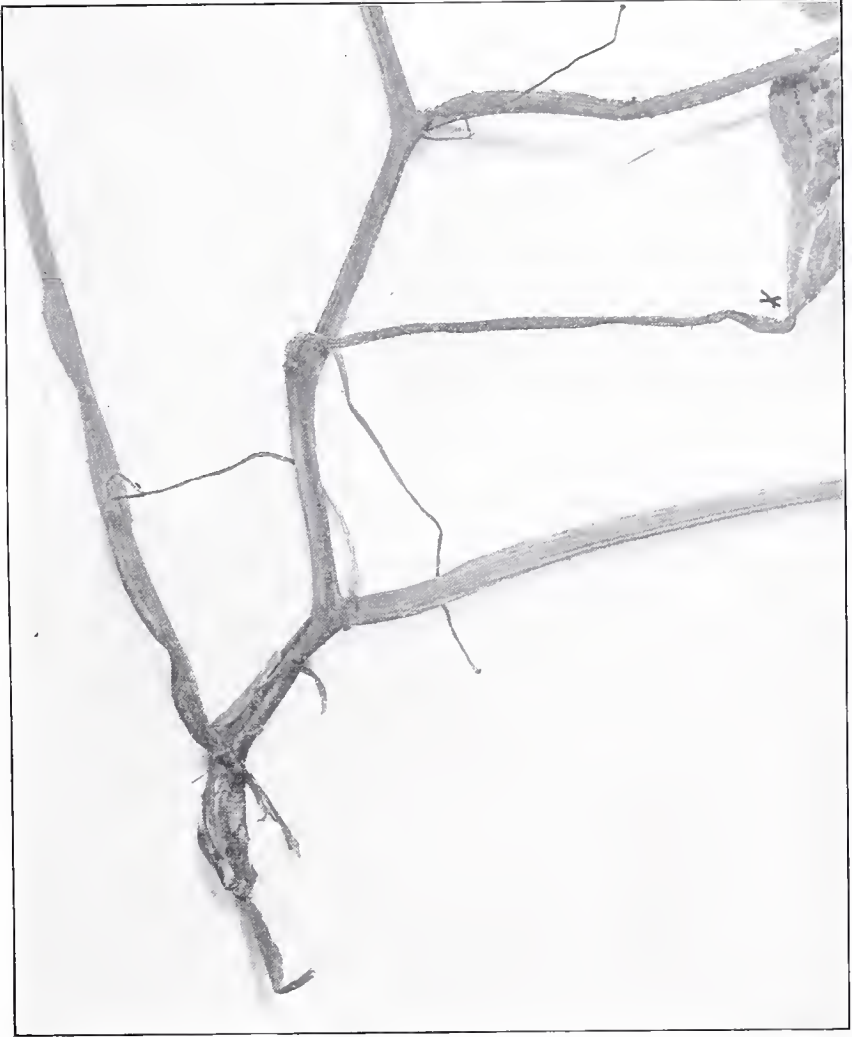


Fig. 21. Leaf of Pumpkin, showing where a larva entered it at *x* and worked downward and into the vine through the inside of the base of the leaf-stalk. Larva in the vine, at the left, just below the lower shriveled petioles or leaf stalk at the left. One-fourth natural size.



Fig. 22. External evidence of the Squash Borer beginning its work. Note the finely-ground material (*excreta*) on the outside of the vine.



Fig. 23. Larva in vine which it has nearly cut off. One-eighth natural size. (Where lines from *a* and *b* would cross.)

terial is exhausted before proceeding to another place to repeat the operation.”—(Prof. J. B. Smith.)

It is remarkable as being the only herbivorous Lady-bug. All other species are insectivorous and beneficial. In both the larval and adult stages it feeds on the leaves of nearly all the cucurbits, and pupates while attached to the leaves.

It is killed by applications of any of the arsenites, the same as are the other Coleoptera or beetles here discussed, and is likewise prevented by covering the plants. It is killed under the paper tent, Mechanical Device No. 2.

ORDER COLEOPTERA: The Beetles.

FAMILY CHRYSOMELIDÆ: The Leaf Beetles.

The 12-Spotted Cucumber Beetle (*Diabrotica 12-notata.*) Fig. 26.

The adult of this insect is a greenish yellow beetle, with six black dots on each wing-cover. It is very common on a great many kinds of plants. The adult beetle feeds on foliage, and the larva feeds on the roots of plants. It pupates in the ground and remains there during the winter. There are two broods each year, the adults of the second brood appearing during the first half of August.

The effects of this insect, the remedies to be employed, and the enemies of this insect are the same as those of the next species.

The Striped Cucumber Beetle (*Diabrotica vittata.*) Fig. 27.

This is one of the earliest and most destructive insects attacking cucurbitaceous plants. It injures all species of plants of this family as well as of some others. The beetles are about one-fourth of an inch long and are yellow, with two black stripes extending lengthwise on each wing cover.

They are too well known to need detailed description. They appear on plants by the first of June, or as soon thereafter as the young plants come above ground, and commence at once to eat ragged holes into the leaves and even to chew off the young stems. (Fig. 28.) They pair by the middle of June and continue breeding throughout the summer, there being two distinct broods which overlap and are thus indistinctly demarcated. In central Pennsylvania the second brood commences to appear about the second week of August. The adults feed on the leaves and tender vines and lay their eggs in the ground. (Fig. 29.) The larvæ feed on the roots and often cause the plants to wither and die without apparent cause. (Fig. 30.) If the

earth is carefully removed from around the wilted plant the small white "worm" may be found, and the rootlets and soft outer portion of the roots will be found eaten away. (Fig. 31.) They pupate in the ground and hibernate as adults.

The earliest remedy is mechanical protection (No. 1) by a net or cloth with finer mesh than the common coarse mosquito netting.

The adults can be killed by the arsenites (1—5), also by tobacco (11), lime (14), land plaster (13), and they can be prevented by the various methods under "Farm Practice." The larvæ can be killed by using tobacco dust or pulverized stems in the soil around the hill. We have had decided success by sticking a few holes four or five inches deep in the ground around the hill and putting about a teaspoonful of calcium carbide in each and filling again with earth. Land plaster and turpentine are also preventives. A pinch of nitrate of soda in each hill acts both as an insecticide and as a fertilizer.

Ground Beetles (*Harpalus*) and their larvæ destroy many of the larvæ and pupæ.

(See general Remedies and Preventives given later.)

ORDER COLEOPTERA: The Beetles.

FAMILY CHRYSOMELIDÆ: The Leaf Beetles. (Fig. 32.)

The White-striped Flea-beetle (*Systema blanda*). The Elongate Flea-beetle (*Systema elongata*), and The Cucumber Flea-beetle (*Crepidodera cucumeris*.)

As all the Flea-beetles belong to the same sub-family and as their habits, life histories, effects and remedies are similar we here treat them together. They can be known by their very small size and the enlarged segment (femur) of the hind leg, with the fact that they are able to jump and suddenly disappear like fleas (hence the common name), although their jump ends in a short flight. The White-striped Flea-beetle (*Systema blanda*) is one of the commonest and most destructive. (Fig. 34.)

They are the first insects of the spring to attack the plants, eating fine round holes in them before the leaves have expanded and consequently inflicting considerable injury. As the leaves grow the holes enlarge and become conspicuous with brown edges. (Fig. 33.)

The larvæ of most species mine in leaves, feeding on the fleshy substance between the two outer coverings, but they do not effect much



Fig. 24. Terminal portion of the vine shown in 22, growing after it had been cut off near the original root. It continues to grow because it was covered with earth near the portion shown at the right and just below the center. It was well-rooted there.

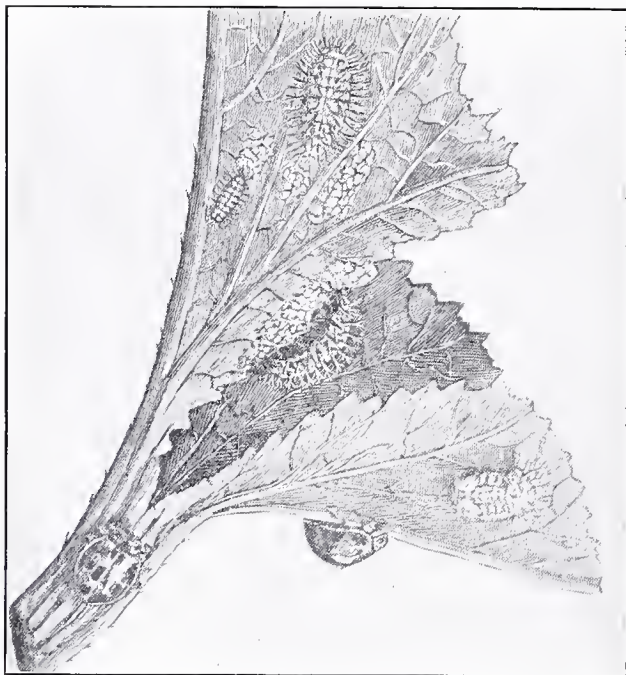


Fig. 25. The Herbivorous Lady Bug (*Epilachna borealis*). From Comstock's "Mannal of Entomology."



Fig. 26. Spotted Cucumber Beetles (*Diabrotica 12-notata*), adult Males and Females. Twice natural size. The two at the left are males; at the right are females. Those above show the dorsal or upper side; those below, the ventral or lower side. There are artificial bands, due to reflection of light.



Fig. 27. The Striped Cucumber Beetle (*Diabrotica vittata*), natural size. The two above show the dorsal or upper side, and the two below show the ventral or lower side. The two at the left are males, and the two at the right are females.

damage. The one generally called "The Cucumber Flea-beetle" (*Crepidodera cucumeris*), prefers potato leaves to those of cucumbers. (Fig. 35.)

Although the adults are very small they often appear in such numbers as to prove quite serious. They are too small to be kept out by netting unless very fine gauze or cheese cloth is used. On account of the readiness with which they jump with the wind they can be destroyed by thousands by Mechanical Device No. 3.

They are biters or chewers and hence can be killed by the arsenites. The remedies are the same as for the striped cucumber beetle. Bordeaux mixture is good, besides acting as a fungicide or remedy for plant disease. The tobacco decoction and arsenate of lead are also to be especially recommended.

ORDER DIPTERA: The Flies.

Whenever decay commences in any part of cucurbitaceous plants, several species of fly larvæ or "maggots" may be found. They are whitish, footless and headless grubs, without jaws or appendages. They live in the liquids that accompany decay and feed upon these and the decaying tissues. They need cause no alarm, as they are more the result than the cause of the trouble where they occur.

Sometimes one may see a wilted young plant, and upon digging into the ground find it nearly cut off an inch or two beneath the surface, and in the wilting stem, toward the top, may be found a single fly larva. This is there because the Cucumber Beetles had bitten the plant partially off and left a suitable place for the adult fly to deposit its egg.

No remedy is necessary but excessive seeding prevents disastrous results from the effects of the Cucumber Beetles and any other insects that would cut off some of the young stalks.

PREVENTIVES AND REMEDIES.

A preventive is something that keeps an insect away from the crop, and a remedy is a means of destroying it after it is present. All that we wish here to indicate is how to produce a crop of Cucurbits by successfully combatting the hosts of insects that yearly become more serious. The means to be employed may be classed in one or more of three groups, which for want of better terms we designate as (1) Mechanical Devices, (2) Farm Practice and (3) Insecticides. These overlap, and it may be difficult to tell to which some of the later suggestions may belong, but as we have tried most of them and have found them reliable we know that they can be used with safety and with feelings of security.

I. MECHANICAL DEVICES.

1. A Covering of Netting for Protection.

The netting is especially important for young plants, as it protects them from insect attacks until they are well started, when the injuries will not be so perceptible. Closely-woven mosquito netting will do for all insects but the flea-beetles and thrips, but for these pests finer material must be used. A nice way to put up the net is to cut it into squares as large as desired (about three feet each way), and stick into the ground both ends of two pliable sticks bent into semi-circles and crossed at right angles at the top like the central wickets of a croquet ground. Cover them with the netting and place loose earth on the edge all the way around to hold it down. (Fig. 37.)

Another and quicker method is to incline a single stake over the plants and push or drive it into the ground. Over this place the netting and cover the margin with loose earth. (Fig. 38.)

Another method of covering plants has been highly recommended by Prof. C. M. Weed and others. It consists in covering two end-boards with netting and attaching a stake to each to hold it upright when pushed into the soil. This gives a box-shaped cover with only two ends of wood, the top and two sides being netting. It has the advantage of being portable and readily packed in compact space for use another year. The mode of construction and use is shown by Fig. 39. We have not found it more effective than some of the more simple devices here mentioned, especially that of Fig. 38.

With all kinds of netting it is essential that the meshes be small enough to keep out the insects and that the edges be well covered with earth so the insects will not crawl beneath them.



Fig. 28. Effects of the Striped Cucumber Beetles on young plants. At the center and toward the upper right corner of the picture are shown small plants that are wilting because they are partially cut off just beneath the ground by these Beetles when the latter entered it to deposit their eggs.

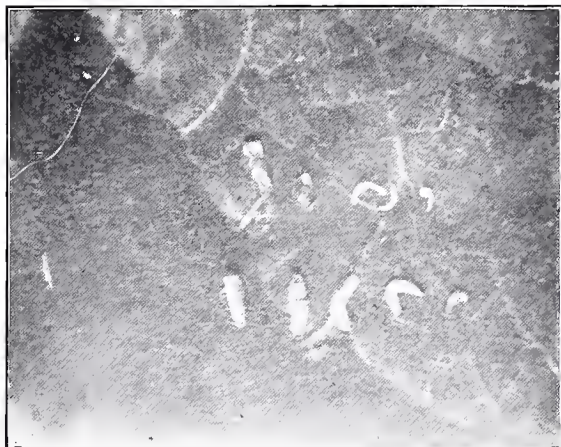


Fig. 29. Larvæ of Striped Cucumber Beetles, nearly natural size. These were taken from the ground at the same time and indicate differences in age in accordance with the differences in size.



Fig. 30. Effects of the Larvæ of the Striped Cucumber Beetle on older Cucumber Plants. The vine in the fore-ground is wilting without apparent external cause.

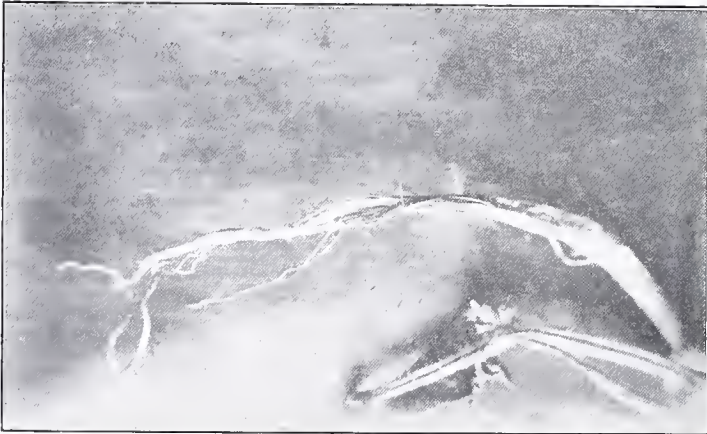


Fig. 31. Roots of the Vine shown in Fig. 30, showing that all of the softer outer substance and most of the rootlets have been eaten away by Larvæ of the Cucumber Beetles.

A third and still quicker and therefore more economical method is to simply place the netting loosely and unsupported over the plants and fasten it down with the loose earth. It should be pulled up at the middle once about every three days in order to relieve the pressure on the plants, but if it does not rain on the earth and fasten it down the plants will exert sufficient pressure to support the netting for themselves. After a few weeks it can be removed and stored for another year. This method appears almost as effective as any, and we have tried all. (Fig. 40.)

2. The Paper Tent.

We have recently devised and tested this "tent" and consider it effective for all kinds of insects on plants small enough to be tightly covered by it. We used large sheets of brown paper thirty by thirty-six inches, procured at a newspaper office. Each is folded twice to make a block of four sheets one-fourth the original size. Then a diagonal fold is made from the corner that was the center across to the farthest corner. (See Ill. No. 41.) When this is properly unfolded and partially spread it will stand upright like a tent. About two tablespoonfulls of carbon bisulphide are poured on the ground around the plants in the hill and the paper tent is quickly placed over them and its edges covered with earth. Two persons can place one hundred tents in an hour, and by that time every living insect (except the borers) will be killed under the first that were placed and the workmen can commence to cover other plants with them. Carbon bisulphide and calcium carbide are especially effective when properly used with this device. It can be used over any and all kinds of plants that it will cover and the insects thereon will be killed, no matter what species, and the plants will not be injured. It is here described for the first time. If larger plants are to be treated two or more sheets may be pasted together. They can be stored in tight boxes away from mice and kept in use for many years. (Ill. 41.)

3. The Tarred Board. (Ill. No. 42.)

This device is a modification of the tarred cloth and for some reasons is preferable. Thin boards are nailed on a cross pole in such a way as to give a flat surface about thirty inches wide by forty inches long. Over the broad board thus made tar or pitch is to be smeared. When a person carries this tar board by the pole or handle with the tarred side toward plants and another person from the windward side of the row brushes insects toward it they strike it and are killed by thousands. It can be operated successfully by one person. (Fig. 43.)

This is especially recommended for thrips, flea-beetles, striped cucumber beetles and plant lice. It can be used to advantage for

such insects as these on any kind of plants, but those insects, like plant lice, that do not jump readily must be brushed against it. This is such a cheap and effective device that it should come into general use.

4. Board Traps. (Fig. 44.)

Simply flat boards are placed on the ground around plants, and as it is warmer under them at night than in the air above them, insects of certain species congregate there and in the morning may be brushed off into a can or tray of kerosene and water and thus killed at once.

This is especially recommended for squash bugs, cut worms, false army worms, crickets, slugs, etc.

II. FARM PRACTICE.

1. Clearing up all Rubbish.

It is particularly important that this be done late in the fall and in the winter. If debris of all kinds available then be raked together and burned many hibernating insects will thus be killed. However, it is advisable that a watch be kept for toads which hibernate under leaves, etc. These animals are of great value as destroyers of insects and slugs and they should be preserved with care. They are too frequently burned with leaves and rubbish in the winter time.

Rail fences are favorite places for insects like the squash bug to pass the winter in hibernation, as well as favorable to the growth of weeds. Wire and board fences can be kept cleaner and consequently will contribute toward keeping down insect pests.

2. Clearing Away Unused Portions of Crops.

Just as soon as the desired portion of a crop is gathered the remaining parts of the plants, green fruits, stems, leaves, roots and all, should be burned, buried or thrown in a heap to decay. The late fall brood of nearly all species of insects mentioned in this Bulletin would be reduced if this practice were general. This means that but few individuals would be able to live through winter and infest the crops for a new brood in spring.

If at any time plants or parts of plants are killed by insects they should be burned at once. This is a general principle of great importance and applies to all crops.

3. Killing all Weeds.

Since some of the insects (particularly the plant lice and flea-beetles) mentioned above feed on several kinds of weeds it is very important that the premises be kept free from weeds, because otherwise the pests are able to multiply on the uncultivated plants and from them, constantly come to infest the cultivated crops.



Fig. 32. Several Species of Flea Beetles, ten times natural size. Taken with a micro-photographic camera. In the left hand column the dorsal side or back is shown, and in the right column the ventral or under side is shown. Note the enlarged thighs of the hind legs, adapted to jumping. The top picture is a pair of Striped Flea Beetles (*Systema blanda*), while the second and smallest pair is the Cucumber Flea Beetle (*Crepidodera cucumeris*).



Fig. 33. The Characteristic Effects of the Flea Beetles on Young Beans; one-half natural size.



No. 34. The White-striped Flea-beetle (*Systema blanda*). Natural size. The dorsal or upper side is shown by the upper pair, and the ventral or lower side is shown by the lower pair. At the left are males; at the right, females.



Fig. 35. The Cucumber Flea Beetle (*Crepidodera cucumeris*) and its Effects on Potatoes. Note that all the Flea Beetles prefer leaves of Potatoes and Beans to those of the Cucurbitaceous Plants.

4. Rotation of Crops.

This practice should be followed for the sake of the strength of the plants if not for the repression of insects. Many pests stay in one locality, and if the same kind of crop is grown consecutively for many years in the same soil the insects accumulate there and become most serious.

To rotate with plants that are similar and attacked by the same insects will not avail much. The plants should be of widely different character and any insects that remain are thus starved.

5. Planting Trap Crops.

This is done in two ways. One is to make a very early planting of the kinds of plants to be set out later, intending to have the insects infest this trap crop with their eggs and then destroy them. Often it is desirable to start the trap plants indoors in order to have them large enough for the insects to attack at once. Sometimes it is desirable to spray the trap crop with kerosene or some other insecticide that will be sure to kill the pests even though the plants are also injured. Often it is possible to gather an early crop from the trap plants before destroying them. For example, it is recommended to plant traps of early summer squash to protect the winter varieties to be planted later.

The other method is to plant some kinds of plants that the insects prefer to the ones we wish to raise. For example, this year we have completely protected our squash from attacks of flea-beetles by planting a few potatoes around among the vines. These insects prefer the potato and other Solanaceous plants to the Cucurbitaceous, and consequently when it was possible went to the former in place of the latter. In fact, that is why we had to photograph a potato and bean leaf instead of one from a Cucurbit to show the work of the flea-beetle. They were serious pests on our squash last year, but this year none occurred on squash, cucumber or melons, all having potato vine traps. This test has never before been made or published.

6. Hand Picking.

This consists in going over the plants every morning during the weeks of the greatest abundance of the insects especially during the mating season, and picking off or brushing the insects into oil and water. This is especially to be recommended for squash bugs. The board traps greatly facilitate this means of gathering the pests. It is the best means of combatting the tomato worm, celery caterpillar and many other conspicuous insects. Clusters of eggs should likewise be picked off.

7. Excessive Seeding.

This consists in the well-known method of planting in one hill more seeds than are to be grown, with the expectation that the insects will destroy some. This is a good plan when it is necessary

but it should not be required as it is better to exterminate the insects. For several insects that are difficult to combat, this practice is often resorted to.

8. Using Fertilizers.

It is very desirable that all plants have a strong, vigorous growth, for they are thus able to withstand the attacks of insects better than can weaklings. Any kind of fertilizer is valuable in overcoming insect attacks because it promotes vigor, but one of the best is a pinch of nitrate of soda in each hill or at the root of each plant. This produces the needed rapid growth and also acts as an insecticide. Tobacco dust is also a valuable fertilizer and insecticide. Its commercial value as a fertilizer is \$25.00 per ton.

9. Starting Plants Early.

The purpose of this practice is to have them as large as possible before the insects appear. An attack that will kill a small plant will but slightly injure a large one. There is an advantage in starting plants indoors in order to have them large enough to withstand insect attacks when set out, besides the early yield of produce.

10. Late Fall Ploughing.

This practice is valuable to destroy those insects, such as the Squash-borer, the Striped Cucumber Beetle and perhaps the Spotted Cucumber Beetle, that pass the winter in the ground. If they are turned over and exposed during the winter a great many insects are killed by ploughing in the fall. Those that pass the winter as pupæ are especially likely to be killed by the breaking up of their pupal cases or cells.

11. The *early* Application of all Preventive and Remedial Measures.

The importance of this can not be too greatly emphasized for all species of insects, and there are many that can not be successfully combatted unless practical measures are taken as soon as they make their appearance. Among these are such as the Plant Lice or Aphids. In June while the vines are small and the Aphids first migrate to melons, etc., from their food plants of winter and spring, they can readily be killed by fumigating the vines or spraying as directed elsewhere in this Bulletin; but if this is neglected until the vines are large and fruit is set it is almost impossible to rid the field of the pests.

III. INSECTICIDES.

As stated in the early part of this Bulletin, insecticides are of two general kinds, according to the structure of the mouth and the feeding habits of the insect to which they are to be applied. Those species that chew their food can be killed with internal poisons (A), if they live where they can be reached; and those that are suctorial must be killed by contact applications (B).



Fig. 86. Fly Larvæ and Pupæ, of different species, but such as may be found in any part of a Cucurbitaceous Plant as soon as it commences to decay. They probably hasten the decay, but are not the original cause. At the right are eggs, in the center are larvæ, and at the left are pupæ.



Fig. 37. Frame on the right, and net over frame on the left, showing how pliable twigs may be used to form an inverted basket to hold netting which protects plants from insects.



Fig. 38. Inclined Sticks at right, and a similar device covered with netting at left. The simplest, cheapest, quickest, and most satisfactory means of supporting netting over plants.

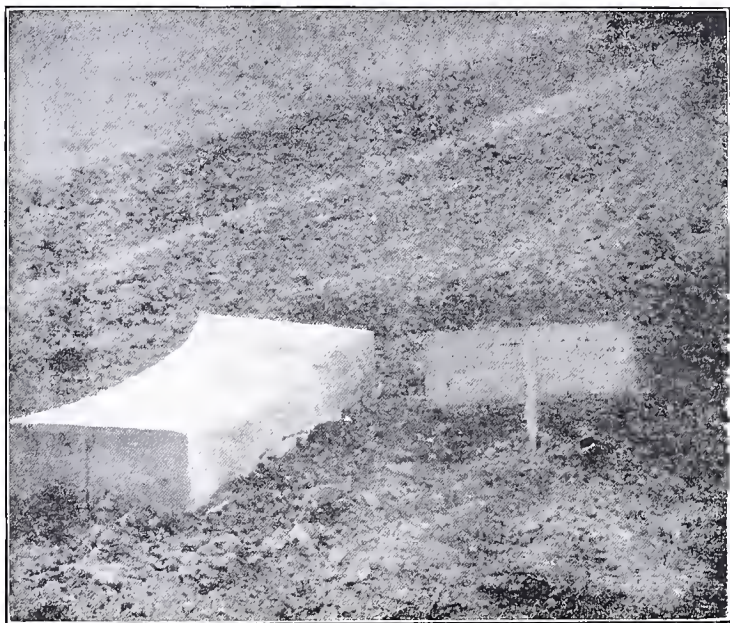


Fig. 39. Netting attached to End-Boards, covering Plants as an inverted box. Also, one End-Board not covered, showing method of attaching sharpened stake to hold it upright when stake is pushed down.

It should be remembered that most substances that kill insects will also kill plants if applied in sufficient strength. Fortunately there is a safety limit of strength at which insects are killed and plants are uninjured. Our object should be to apply insecticides of such strength as to have the desired effect on the pests, but to save the plants. An insecticide should be applied at the proper time and for a certain kind of insect, and should be selected in accordance with the recommendations made for the destruction of the specific kind of insect under contemplation.

A. Internal Poisons or Stomach Poisons, for Chewing Insects.

1. Paris Green. The poisons that contain arsenic are called Arsenites and Arsenates. Paris green is the arsenite of copper and contains about 69 per cent. of arsenic. It can be applied as either (a) a powder, or (b) in liquid.

(a) Paris Green as a Powder: This is to be dusted on the plants, but it should be mixed with some diluting powder in proportion of one part of Paris green to from 20 to 50 parts of the dilutant. On a small scale, flour is generally used, but air slaked lime, land plaster and even road dust or wood ashes are good. It will adhere to the leaves better if applied early in the morning while the dew remains or just after a shower of rain, while they are yet damp. It is washed off by a dashing rain and should be repeated after each rainfall. If there is no rain it is well to repeat the dusting about once every two weeks.

For applying dusts or powders a "powder gun" or bellows will prove useful but not essential. Small hand "puffers" for this purpose are common in stores. A good method is to put the powder into a thin cloth sack or coffee bag, carry it over the plants to be dusted, and pound it with sticks. Especial care should be taken to dust it over the vines of plants for the young borers when they first hatch and commence to eat their way toward the inside of the plant. This is the only opportunity to kill them without cutting them out or piercing them with a sharpened wire.

(b) Paris Green in a Liquid: The Cucurbitaceous plants are very tender and easily injured. Therefore Paris green can not be applied to them in as strong a mixture as to apple trees, but it must be diluted, as for peaches and plums. The formula for vines is:

One pound Paris green to 200 gallons of water, or 4 ounces to 50 gallons. Stir the poison well into the water, then mix with a little water an amount of air slaked lime equivalent to that of the Paris green used, and stir the "milk of lime" into the poisoned water. This is to prevent burning the tender foilage. It **MUST** be applied as a spray and not merely sprinkled on the plants. The work can pro-

perly be done by any spraying apparatus that will throw a genuine spray or mist. A knap-sack sprayer should be on every farm.

2. London Purple. This is mostly composed of an arsenite of lime, and contains about forty-two per cent. of arsenic. It is therefore not as strong as Paris green and is cheaper. A little more of it must be used in making up mixtures, and the lime should never be omitted. It is to be applied either as a powder or liquid, just as is Paris green.

In applying nearly all insecticides used with water it should be remembered that they are not dissolved but are merely held in mechanical suspension, and it is therefore a mixture instead of a solution. The liquid should be well stirred frequently to prevent the poison settling at the bottom. If it is not stirred often it will settle at the bottom of the vessel and the last to be used will be much stronger than the first.

3. Arsenate of Lead. Do not put this into metal vessels or they will be corroded. Wood or glass can safely be used. Formula:

4 ounces of 50 per cent. arsenate of soda.

11 ounces of acetate of lead.

150 gallons of water.

Dissolve the acetate of lead and arsenate of soda separately, each in four quarts of water, in wood, glass or earthenware, then stir them into the remainder of the water in the larger vessel. Apply as a spray as with other poisons. All such substances should be labelled and kept out of the reach of children, poultry or live stock, as they are deadly poisons. If they were not poisonous they would be of no avail for the purposes to which we propose to put them.

It is safe to spray all plants, even cabbage, with such applications, but they should be well washed with dashing water before being eaten or should not be gathered within two weeks from the time of the last application.

4. Arsenite of Lime. This can be made according to the following formula:

1 pound white arsenic.

2 pounds quick lime.

1 gallon water.

Boil this mixture forty-five minutes. (It will not injure metal.) Keep it in a closed vessel, as a jug, properly labelled "Poison," and whenever it is needed use it in proportion of one quart to fifty gallons of water. It can be kept as long as desired, and will be found quite effective for all kinds of biting insects. We have not yet had opportunity to try this substance, but it is so highly recommended by those who have tried it that we do not hesitate to endorse it as a first class insecticide.

5. The Bordeaux Mixture and Paris Green: This has the advantage of being both a fungicide for plant diseases and an insecticide for

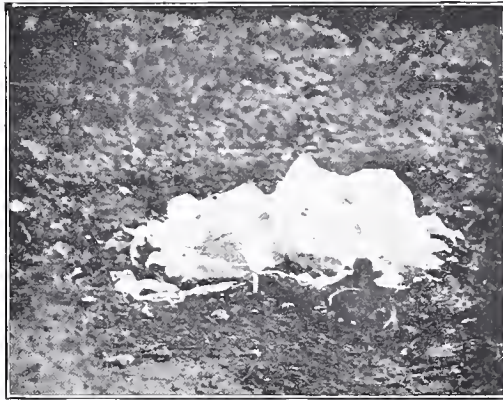


Fig. 40. Netting Material Lying in loose Folds over Plants, without support. Note that with all kinds of Nets the edges must be carefully covered with fine soil. Common Mosquito netting is too coarse to keep out Thrips, Plant Lice, and the various small Beetles.



Fig. 43. Tarred Board, operated by one person. This is effective if properly and carefully done. After using this ten minutes, there were over two hundred insects on one square foot of the board.



Fig. 41. Paper Tents for Fumigating Plants. The Methods of Folding is shown by the one held in the hand of the assistant.

their insect pests. It is in common use. The Bordeaux mixture itself without the Paris green is a fungicide rather than an insecticide. The former is made as follows:

- 4 pounds copper sulphate (blue vitriol).
- 4 pounds unslaked lime.
- 25 gallons of water ("full strength solution"), or
- 50 gallons water ("half strength solution").

Do not use metal. Dissolve the copper sulphate in water. Solution can be hastened by heating. Slake the lime separately in enough water to make a "cream." Pour the copper solution into the larger vessel of water, and strain the "milk of lime" into it through a fine sieve or cloth, stirring the liquid into which it is strained.

Whenever lime is to be used in any substance to be applied as a spray it should first be strained carefully to prevent it clogging the nozzle.

To complete the mixture as an insecticide use four ounces of Paris green to every fifty gallons of the Bordeaux mixture as made according to the formula here given.

This mixture is particularly recommended for Thrips, Flea-beetles, etc.

B. Contact Applications, for Suctorial Insects.

6. Kerosene Mixture with Water. It has recently been determined that it is not necessary, in combatting most insects, to take the trouble of making a kerosene emulsion (7), as a mere mechanical mixture of oil and water is sufficient if the kerosene is thrown in a very fine spray. The mixing is done by the apparatus as it throws the spray, the kerosene being carried in a vessel separate from the water. Several devices for this purpose are now on the market, but one of the best is the Kerowater Knapsack Sprayer. It can be purchased of most dealers. It can be set to make the mixture of any desired percentage. For Cucurbits it should not be used above eight per cent., and five per cent. will generally be found strong enough. Wherever the insects are not on plants that are to be kept growing it can be increased to twenty per cent. and will then prove certain and speedy death. It is particularly recommended for Squash-bugs. Even though plants are to be burned after frost, they should first be well sprayed with a strong mixture to kill the bugs that then collect on them and would remain over winter to infest the next spring's crop.

7. Kerosene Emulsion. This is a famous remedy for all kinds of suctorial insects. Formula:

- $\frac{1}{2}$ pound hard common coarse laundry soap.
- 1 gallon water.
- 2 gallons kerosene.

Shave the soap fine and dissolve it in the boiling water. Pour it into the kerosene (away from fire) while hot, and churn it through a force pump or sprayer until it becomes a thick creamy mass. It will keep as long as desired. For use, thoroughly mix one part of this with nine of water. Apply as a spray, thoroughly, to all parts of the plants and on both sides of the leaves. It must come into contact with the bodies of the insects in order to kill them. It is especially recommended for plant lice and Squash-bugs, but will kill all kinds of insects with which it comes into contact. It has the advantage of the kerosene mixture in the fact that it is not as liable to injure foliage.

8. Whale-oil Soap. This is made by dissolving two pounds of the potash whale-oil soap in one gallon of hot water. It is applied either as a spray or as a wash. As the latter, it can be applied with a brush, but it is a winter wash, mostly for scale insects, and under no circumstances should it be applied to delicate leaves. When Squash-bugs are not on the living plants they can be killed with this.

9. Carbon Bisulphide. This is explosive with fire. It kills by its poisonous fumes, which are heavy. It is especially used to destroy insects in stored grain, but can be employed as a fumigant. One teaspoonful in any kind of a vessel or a clam shell under each of the tents described as Mechanical Device No. 2, will kill every kind of insect present in less than an hour and will not injure the plant. It should be sold by retail druggists at twenty-five cents per pound, or less.

10. Gasolene and Benzine. The fumes of these substances kill insects, but they should be left long enough to insure death, or should be buried or burned when stupefied. Gasolene is the cheapest substance that can be quickly used under tents described as Device No. 2. When it is poured on the ground a greater quantity is needed than when placed in vessels.

11. Calcium Carbide. This is the substance that is used with water to generate the acetylene gas that is now used for illuminating purposes. We do not know of its previously having been used in this country as an insecticide, but our experiments demonstrate its value for this purpose. For insects infesting the soil, a smooth and sharpened stick should be pushed into the ground to as great a depth as they are found (generally from four to six inches), and a teaspoonful of the carbide should be dropped into the hole and the latter then firmly filled with damp earth packed into it. The carbide readily absorbs moisture from the earth and generates gas which permeates the earth and kills all kinds of insects found therein, as does carbon bisulphide. We have killed most of the larvæ and pupæ of beetles around cucumber roots by four or five holes around each hill.



Fig. 42. Turned Board, used by two Men, for Thrips, Flea Beetles and Plant Lice. A cloth soaked with kerosene, pitch or tar and supported by a frame will also be effective.



Fig. 44. Board Trap, showing effectiveness for Squash Bugs.



Fig. 45. Cucumbers and Beans, growing simultaneously not fifteen feet apart. Note that the Beans are seriously injured by Flea Beetles and the Cucumbers are not attacked. This indicates the value of a few beans, potatoes, and early squash or pumpkins as trap plants to take insects away from the more desirable crop to be planted later. Compare with Fig. 33 for the Beans.

For all kinds of insects on plants above ground, use the paper tents described as "Mechanical Device No. 2," and put under each about a teaspoonful of carbide, either on damp soil or in water, and leave it for an hour. Vegetation is not injured.

12. Tobacco. This is a good insecticide for certain species when used either as a fine dust or in a decoction. It will not injure the plants, and will act as a valuable fertilizer. It should come into contact with insects above ground, as they will not eat it.

For insects feeding beneath the surface of the soil nothing is better than tobacco stems or dust placed around the plant and stirred into the soil. They do not eat it, but can not avoid coming into contact with it. The stems can be procured at little or no cost from cigar factories. Stems are as useful as any part of the tobacco plant in making a tea or decoction. This should be applied as a spray.

13. Sulphur. This is often applied as a powder, but is too expensive for general application on a large scale. It is not necessary to use the pure "flower of sulphur, or powder form, but it may be mixed with several times its bulk of some kind of dust, as directed for Paris green, although the proportion of the dilutant must be only about one-third as great.

14. Land Plaster. This is recommended more as a repellant than as a remedy. It is also a fertilizer. It is applied by sprinkling it on the plants or sowing it broadcast over the field. When it is sown with the wind it drives certain species of insects to plants and weeds to the leeward. It is more effective as a repellant if some turpentine or kerosene be mixed with it.

15. Air-slaked Lime. This is used as in Land Plaster (No. 14), and is even more effective. The Cucumber Beetle, especially, is driven before it, and can be kept away from the plants by its frequent use. Of course, a repellant only drives insects away, and does not kill them.

This means that they become more abundant upon the plants to which they are thus driven, but it sometimes a good plan to drive them to one side of the field and there spray with some killing insecticide, according to that recommended for the species in question.

OTHER INVERTEBRATE ANIMALS INJURING CUCURBITACEOUS PLANTS.

Besides the insects discussed in the preceding text, we have found two species of slugs (*Limax*), two of Centipedes and one of Millipeds, injuring the fruits of cucurbitaceous plants by eating into them.

They are especially bad when the weather is very damp and the fruits lie in shaded spots. (See Fig. 47). The young squash shown in Fig. 47 was attacked by all of these pests, which were present upon it at the time it was photographed, but as they were crawling they are not plainly shown.

The remedy is either a spray of Paris green upon the fruits, or better, a layer of wood ashes or other light dusty material on the ground around the hill and under the fruits. The latter can be regarded as a specific against these pests.

We have found some of our young plants cut off and pulled into holes by earthworms. It is a sure indication of their work to find the vegetation drawn into small, round and smooth holes. (Fig. 46.) They can be killed by salt water poured into the holes.

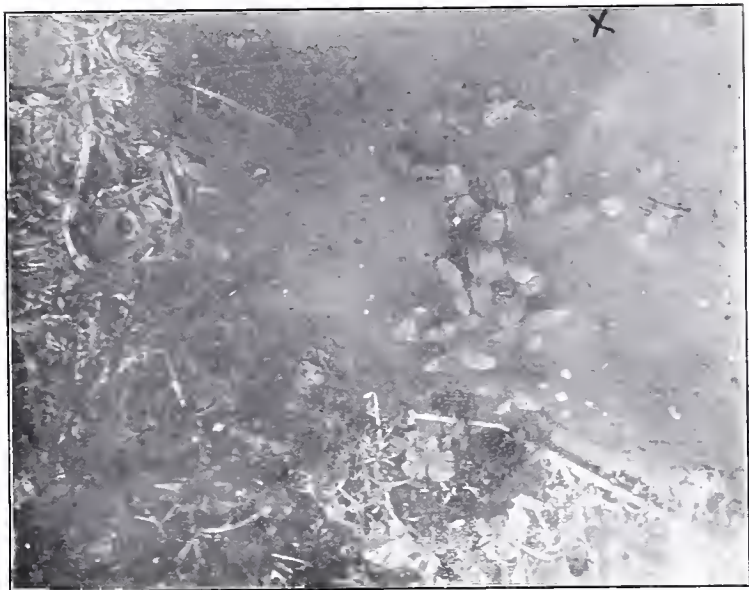


Fig. 46. Young Cucumber Plants Eaten by Earthworms. At the farther end of the straw from *r* were two holes of earthworms with portions of small Cucumber plants and other vegetation cut off and sticking in them.



Fig. 47. The Young Fruit of Squash, eaten by Millipedes, Centipedes and Slugs, all of which were alive upon this at the time it was photographed, but as most of them were moving they are not plainly shown.

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